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New records of armored scale insects, *Pseudaulacaspis* MacGillivray (Hemiptera: Diaspididae), in Korea

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Abstract. *Pseudaulacaspis kiushiuensis* (Kuwana), *Pseudaulacaspis latiloba* (Takagi and Kawai) and *Pseudaulacaspis ulmicola* Tang, occurring on *Quercus*, *Carpinus* and *Zelkova* plants are newly documented in the Korean fauna of armored scales (Hemiptera: Diaspididae). Characteristics of these species are briefly redescribed and illustrative photographs and information on their distribution and hosts are provided. A dichotomous key to species of *Pseudaulacaspis* from Korea is given for correct species identification. In addition, the current status of *Pseudaulacaspis forsythiae* (Kanda) and *Pseudaulacaspis nishikigi* (Kanda) in Korea is discussed based on the results of a survey of the armored scales of Korea and related papers.

Key words. *Pseudaulacaspis kiushiuensis* (Kuwana), *Pseudaulacaspis latiloba* (Takagi and Kawai), *Pseudaulacaspis ulmicola* Tang

Introduction

The genus of *Pseudaulacaspis* (Hemiptera: Diaspididae) was described by MacGillivray in 1921 and currently contains 65 species known worldwide. Of these 72% (47 species) were described from the Oriental region and 26% (17 species) from the Palearctic region. This genus is closely related to the genera *Chionaspis* and *Aulacaspis* and the presence of a pair of setae between the median lobes clearly differentiates it from these genera (Williams and Watson 1988). In Korea, the first record of *Pseudaulacaspis* scales began by Machida and Aoyama (1928) with the report of *Pseudaulacaspis pentagona* (Targioni-Tozzetti) (cited from the publication of Paik (2000)). To date, the following five species have been documented in the Korean armored scale fauna; *Pseudaulacaspis cockerelli* (Cooley), *Pseudaulacaspis forsythiae* (Kanda), *Pseudaulacaspis nishikigi* (Kanda), *Pseudaulacaspis pentagona* (Targioni-Tozzetti) and *Pseudaulacaspis prunicola* (Maskell) (Paik 1978; Paik 2000; Lee 2010). Of these, questions have been raised by Paik (2000) about possible misidentifications of *P. forsythiae* and *P. nishikigi* first recorded in Korea by Kanda (1941a, 1941b). When it comes to economic importance, the false oleander scale (*P. cockerelli*) and the white peach scale (*P. pentagona*) are considered as pests to ornamental trees and shrubs, especially *Taxus* and *Prunus* trees planted as a landscape (Paik 1978; Paik 2000).

In the survey project of Korean armored scales that has conducted from 2006, the following three species of the genus of *Pseudaulacaspis* are newly reported from the Republic of Korea: *Pseudaulacaspis kiushiuensis* (Kuwana), *Pseudaulacaspis latiloba* (Takagi and Kawai) and *Pseudaulacaspis ulmicola* Tang. All of these species were collected on barks of their host plants and they have restricted host range. No economic damage to their host plants was observed during the survey. While conducting the survey of the *Pseudaulacaspis* scales of Korea, the presence of *P. forsythiae* and *P. nishikigi* could not be confirmed because no specimens could be found from collections made from 2006 to present time.

The purpose of this paper is to update the list of the *Pseudaulacaspis* species that occur in Korea, to provide an identification key to species of *Pseudaulacaspis* in Korea, to provide photos, redescrptions for the three species newly documented in Korea, and information on the plant hosts and distribution of species and to review the current status of *P. forsythiae* and *P. nishikigi* in Korea.

Materials and Methods

All slide mounted specimens used for this paper are deposited in the Collection of Plant Quarantine Technology Center. The dichotomous key mentioned below was based on specimens of adult females collected on leaves and barks of their plant hosts. Terminology for morphological structures used in descriptions and an identification key follows that of Miller and Davidson (2005). Here I did not treat two species, *P. forsythiae* and *P. nishikigi*, in an identification key mentioned below based on the results of the current survey of the armored scales of Korea. Photographs were taken using an AxioCam MRc5 camera through ZEISS Axio Imager M2 Microscope and a Leica M165C microscope with Delta pix camera. An asterisk(*) is used to indicate a new distribution record.

Results and Discussion

Pseudaulacaspis kiushiuensis (Kuwana)

(Figures 1–6)

Chionaspis kinshinensis Kuwana, 1909: 155. Type data: Japan, on *Quercus* sp. [Justified emendation; this spelling was corrected by Kuwana (1928) to *kiushiuensis*].

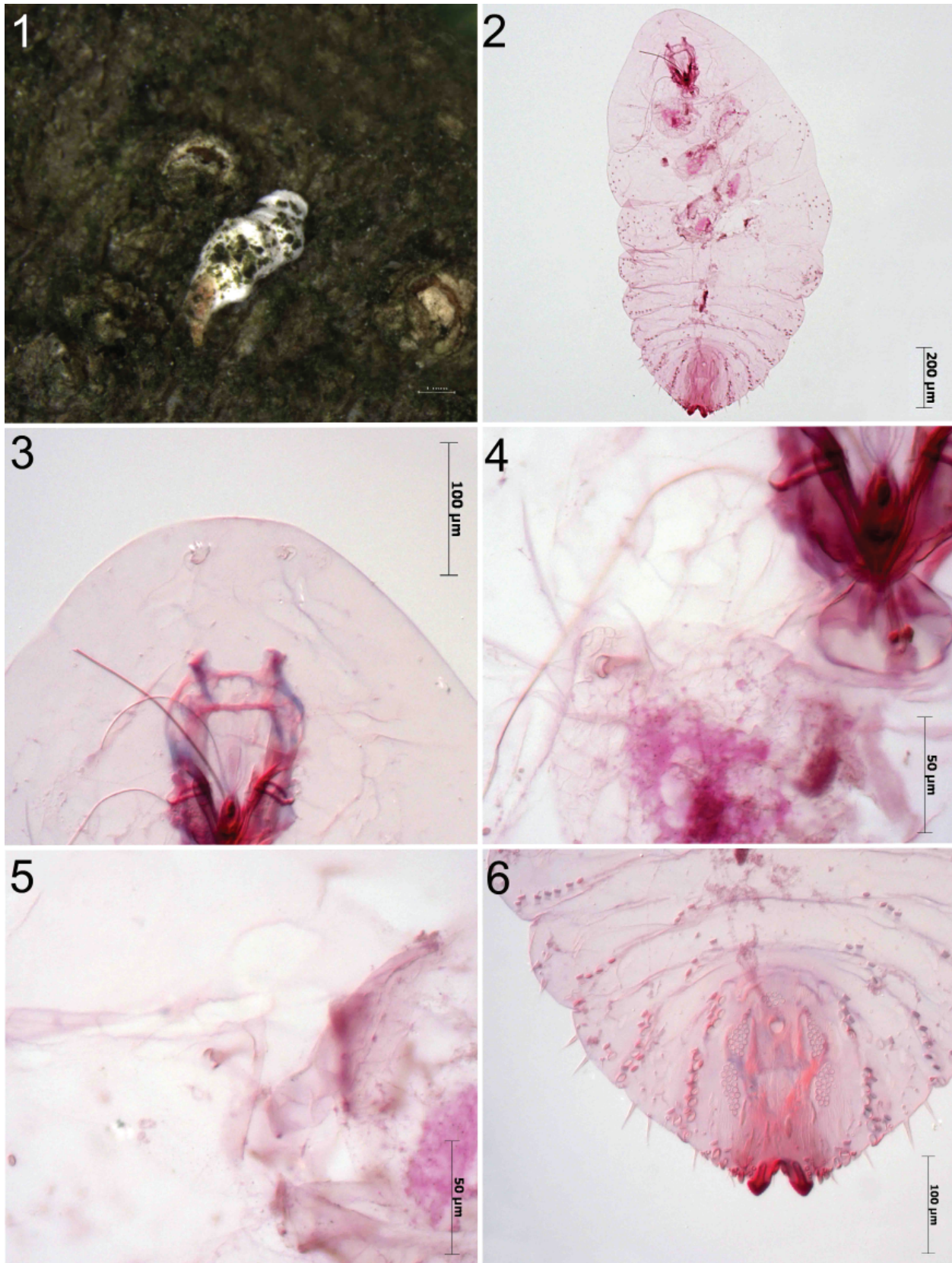
Description. Field Characters. Adult female cover white, oyster-shell shaped; shed skins marginal, yellow to brown. Male (not examined by author) cover smaller, felted, white, elongate, with slight median carina; shed skin yellowish (Kuwana 1917).

Slide-mounted Characters. Adult female with 2 or 3 pairs of well-developed lobes, third lobes sometimes with lateral lobule represented by series of low points; paraphyses attached to medial and lateral margins of median lobules of second lobe. Median lobes prominent with medial yoke, strongly divergent, with 6–8 medial notches, 5–7 lateral notches; second lobes with 2 lobules smaller than median lobes, rounded, much shorter than median lobes. Gland spine formula usually 1–1–1, with about 10 gland spines near each body margin from segments 5 to 7. Macroducts on pygidium about same size without duct between medial lobes, with 10–17 macroducts on each side of body on segments 5 to 7; prepygidial macroducts of 2 sizes, larger size on marginal, submarginal and submedial areas of segments 2 to 4, smaller size on marginal or submarginal areas of mesothorax or metathorax to segments 2 or 3. Perivulvar pores in 5 groups, about 52 pores. Perispiracular pores usually with 3 loculi, anterior spiracles each with 13–16 pores, posterior spiracles absent. Anal opening located at upper of pygidium. Antennae each with 1 conspicuous seta; usually separated by more than maximum width of median lobes. Body elongated fusiform with prepygidial segments each slightly convex laterally. Only found on *Quercus* plants.

Material examined. Korea. GG: Gwanggyosan, 5 adult females on two slides, on *Quercus acutissima* (Fagaceae) bark, 15-v-2006 (B.S. Kim); Sanseong-ri, 2 adult females on one slide, same host, 19-vi-2007 (S.J. Suh). GN: Jinju-arboretum, 2 adult females on one slide, on *Quercus rubra* (Fagaceae) bark, 18-iii-2008 (S.J. Suh); same data except for 1 adult female on one slide, on *Quercus serrata* (Fagaceae) bark; same data except for 8 adult females on two slides, on *Quercus* sp. (Fagaceae) bark; same locality, 6 adult females on two slides, on *Quercus serrata* (Fagaceae) bark, 19-iv-2008 (S.J. Suh); same locality, 2 adult females on one slide, on *Quercus* sp. (Fagaceae) bark, 20-v-2008 (S.J. Suh). JJ: Donnaeko, 2 adult females on one slide, on *Castanopsis cuspidata* var. *sieboldii* (Fagaceae) bark, 16-v-2012 (S.J. Suh); Halla Eco-forest, 2 adult females on one slide, on *Quercus glauca* (Fagaceae) bark, 21-v-2013 (S.J. Suh).

Distribution. China, Japan, *Korea (Ben-Dov et al. 2014).

Hosts. Fagaceae: *Castanea crenata*, *Castanea mollissima*, *Castanea pubinervis*, *Castanea* sp., **Castanopsis cuspidata* var. *sieboldii*, *Quercus acuta*, **Quercus acutissima*, *Quercus gilva*, **Quercus glauca*, *Quercus myrsinifolia*, **Quercus rubra*, *Quercus serrata*, *Quercus* sp. Moraceae: *Morus alba* (Ben-Dov et al. 2014).



Figures 1–6. *Pseudaulacaspis kiushiuensis* (Kuwana). 1) Habitus. 2) Female. 3) Antennae. 4) Anterior spiracle. 5) Posterior spiracle. 6) Pygidium.

***Pseudaulacaspis latiloba* (Takagi and Kawai)**

(Figures 7–12)

Phenacaspis latiloba Takagi and Kawai, 1966: 112. Type data: Japan, on *Carpinus laxiflora*.

Description. Field Characters. Adult female cover white, oyster-shell shaped; shed skins marginal, yellow to brown. Male not examined by author.

Slide-mounted Characters. Adult female with 2 or 3 pairs of well developed lobes, third lobes reduced or represented by series of low points. Median lobes prominent, robust, broadly rounded with medial yoke, divergent, with minute notches; second lobes with 2 lobules smaller than median lobes, rounded, much shorter than median lobes. Gland spine formula usually 0–1–1, with about 6 gland spines near each body margin from segments 5 to 7. Macroducts on pygidium about same size without duct between medial lobes, with 8–10 macroducts on each side of body on segments 5 to 7; submedial ducts on segments 3 to 4, with 6 to 7 ducts each; submarginal ducts on segments 2 to 4, with 10 to 14 ducts each. Perivulvar pores in 5 groups, about 77 pores. Perispiracular pores usually with 3 loculi, anterior spiracles each with 13–27 pores, posterior spiracles each with 6–10 pores. Anal opening located at upper of pygidium. Antennae each with 1 conspicuous seta; usually separated by more than maximum width of median lobes. Body robust fusiform with prepygidial segments little convex laterally. Only found on *Carpinus* plants.

Material examined. Korea. JN: Wando-arboretum, 11 adult females on three slides, on *Carpinus laxiflora* (Betulaceae) bark, 10-v-2007 (S.J. Suh); Jirisan, 2 adult females on one slide, same host, 3-vi-2011 (S.J. Suh).

Hosts. Betulaceae: *Carpinus laxiflora* (Ben-Dov et al. 2014).

Distribution. Japan and *Korea (Ben-Dov et al. 2014).

***Pseudaulacaspis ulmicola* Tang**

(Figures 13–17)

Pseudaulacaspis ulmicola Tang, 1988: 222. Type data: China, on *Ulmus pumila*.

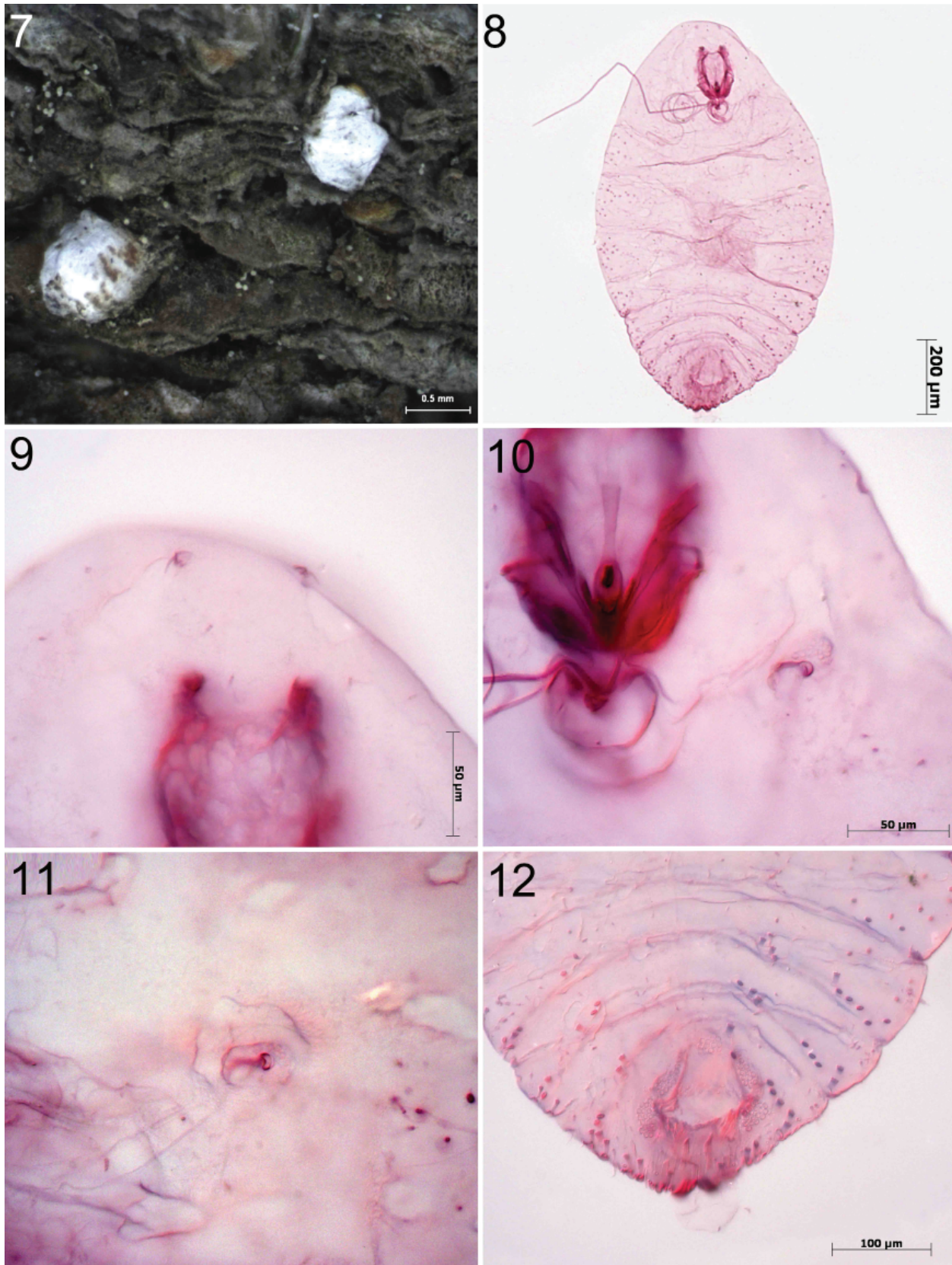
Description. Field Characters. Adult female cover white, oyster-shell shaped; shed skins marginal, yellow to brown. Male not examined by author.

Slide-mounted Characters. Adult female with 2 or 3 pairs of well developed lobes, third lobes reduced or represented by series of low points. Median lobes prominent, rounded with medial yoke, divergent, with minute notches; second lobes with 2 lobules smaller than median lobes, rounded, much shorter than median lobes. Gland spine formula usually 1–2–2, with about 18 gland spines near each body margin from segments 5 to 7. Macroducts on pygidium about same size without duct between medial lobes, with 14–18 macroducts on each side of body on segments 5 to 7; submedial ducts on segments 2 to 4, with 39 to 41 ducts each; submarginal ducts on segments 2 to 4, with 38 to 40 ducts each. Perivulvar pores in 5 groups, about 53 pores. Perispiracular pores usually with 3 loculi, anterior spiracles each with 4–11 pores, posterior spiracles each with 1–5 pores. Anal opening located at upper of pygidium. Antennae each with 1 conspicuous seta; usually separated by more than maximum width of median lobes. Body elongated fusiform with prepygidial each slightly convex laterally. Found on *Zelkova* and *Morus* plants.

Material examined. Korea. GG: Hyohaeng-ro 481beon-gil, Hwaseong-si, 6 adult females on three slides, on *Zelkova serrata* (Ulmaceae) bark, 22-iv-2006 (B.S. Kim).

Hosts. Ulmaceae: *Ulmus pumila*, **Zelkova serrata* (Ben-Dov et al. 2014).

Distribution. China and *Korea. (Ben-Dov et al. 2014).

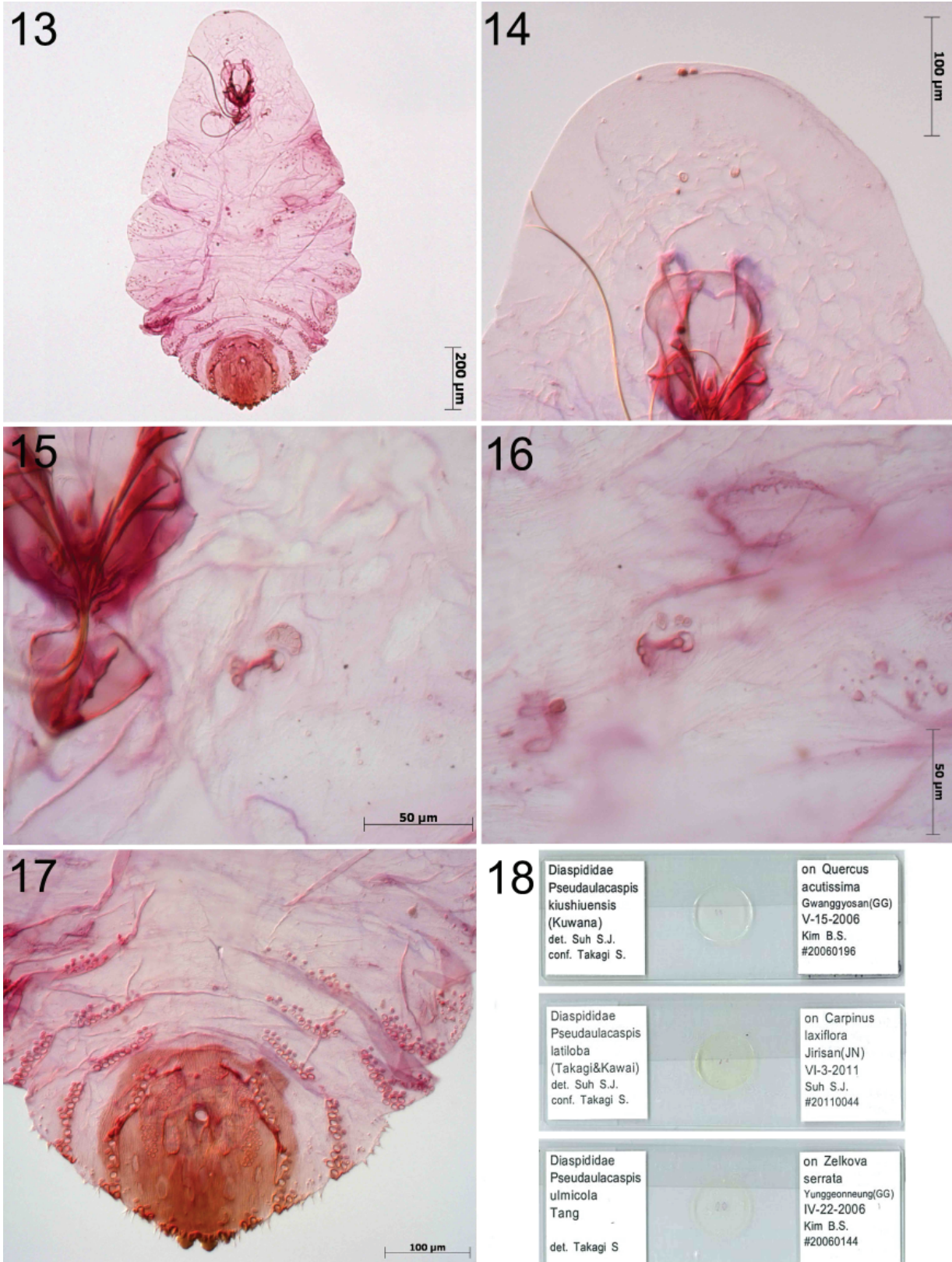


Figures 7–12. *Pseudaulacaspis latiloba* (Takagi and Kawai). **7)** Habitus. **8)** Female. **9)** Antennae. **10)** Anterior spiracle. **11)** Posterior spiracle. **12)** Pygidium.

1.	Body oval or turbinate, length usually less than 1.5 times greatest width	2
—	Body elongate, length usually 1.5 times or more than greatest width	3
2(1).	Third space usually with 1 gland spine; at least 1 bifurcate or trifurcate gland spine in second, third, or fourth space; antennae sclerotized projections apically; with 5–22 (10) small macroducts on each side of the metathorax and segment 1	
 <i>Pseudaulacaspis pentagona</i> (Targioni-Tozzetti)	
—	Third space usually with 2 or more gland spines; simple gland spine in second, third, or fourth space; antennae rounded apically; with 0–15 (5) small macroducts on each side of the metathorax and segment 1 (on usually <i>Prunus</i>) ...	
 <i>Pseudaulacaspis prunicola</i> (Maskell)	
3(1).	With perispiracular pores near posterior spiracles	4
—	Without perispiracular pores near posterior spiracles	5
4(3).	With usually two rows of submarginal macroducts on abdominal segments 2 and 3; with 4–11 pores near anterior spiracles and 1–5 pores near posterior spiracles (found on <i>Zelkova</i> and <i>Ulmus</i>)	
 <i>Pseudaulacaspis ulmicola</i> Tang	
—	With one row of submarginal macroducts on abdominal segments 2 and 3; with 13–27 pores near anterior spiracles and 6–10 pores near posterior spiracles (only found on <i>Carpinus</i>)	
 <i>Pseudaulacaspis latiloba</i> (Takagi and Kawai)	
5(3).	Without a duct on abdominal segment 6; antennae usually widely apart, width between antennae wider than that between median lobes (only found on <i>Quercus</i>)	
 <i>Pseudaulacaspis kiushiuensis</i> (Kuwana)	
—	With duct on abdominal segment 6; antennae usually close together, width between antennae narrower than that between median lobes (on many hosts)	
 <i>Pseudaulacaspis cockerelli</i> (Cooley)	

The updated list of the armored scales known to occur in Korea, including *Pseudaulacaspis kiushiuensis* (Kuwana), *Pseudaulacaspis latiloba* (Takagi and Kawai) and *Pseudaulacaspis ulmicola* Tang which are newly recorded in Korea, adds to our understanding of the Korean fauna of armored scales and aids in the correct identification of species.

The current status of *Pseudaulacaspis forsythiae* (Kanda) and *Pseudaulacaspis nishikigi* (Kanda), reported to first collected from *Forsythia viridissima* Lindl. (Oleaceae) and *Euonymus alata* (Thunb.) Siebold (Celastraceae) in Korea should be reviewed by analyzing information on their described morphological characters. The survey has been conducted over the past 8 years, however, the existence of two species was not confirmed. Only *Pseudaulacaspis cockerelli* (Cooley) was found from these host plants. Although I did not examine the type specimens of these species, based on their description and illustrations, they appear to be very similar to *P. cockerelli*. Such distinctions mentioned in published papers might be considered to be within the range of intraspecific variability of *P. cockerelli*, perhaps due to differences in their host plants or environmental factors. Herein I have addressed as the separate species considering that the problem of *P. cockerelli* complex is still far from settled, however, the morphological variability that occurs in these species should be studied and discussed in more detail to determine if they are indeed the same species or not.



Figures 13–18. Three species of *Pseudaulacaspis*. 13) *P. ulmicola* Tang, female. 14) *P. ulmicola* Tang, antennae. 15) *P. ulmicola* Tang, anterior spiracle. 16) *P. ulmicola* Tang, posterior spiracle. 17) *P. ulmicola* Tang, pygidium. 18) Slide-mounted specimens.

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